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NEW AND SIGNIFICANT SPECIES OF *PARTULA* FROM MOOREA,
SOCIETY ISLANDS

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The present writer has been engaged for some years in an intensive study of the distribution, variation, and evolutionary relationships of the land gastropods belonging to the genus *Partula*. The species dwelling in the Society Islands have received the most attention on account of their number and variety; the known species of the genus number a little over a hundred, and more than fifty of these occur only in the group specified. All of the islands inhabited by the genus, from Tahiti to Borabora, have been explored during one or more journeys, and the volume on the Tahitian species has been published¹. Field studies have also been prosecuted in the Cook, Samoan, Tongan, and the Mariana Islands, and a volume on the species of the last-named group has been completed and is shortly to appear.

The island geographically proximate to Tahiti is Moorea, about twenty miles distant, where collections amounting to over forty thousand specimens have been secured in the course of five field trips, from 1907 to 1923. The detailed study of this wealth of material is progressing rapidly with results that entirely confirm the general conclusions of the Tahitian research,

¹ Carnegie Institution of Washington, Publication No. 228, 1917.

while in addition abundant evidences have been discovered that the differentiation of more than one parental stock into diverse products is a contemporaneous process. Any further statement of the essential facts in the last connection must await the preparation of the complete account of the Moorean species, including the details of their distribution and the quantitative data of their variation.

The purpose of the present article is to place on record certain new species that are so noteworthy as to merit immediate attention. The general point of greatest interest is that they were unknown to Garrett, who resided many years in the Society Islands, and whose circumstantial account of the land gastropods of that group¹ reveals his intimate knowledge of the organisms and of their localized situations. Garrett's descriptions of the Moorean snails show that he explored the island with great care, yet the new species herein described must have escaped his notice on account of the peculiar circumstances of their occurrence. Having corroborated the records of the species of Tahiti, Raiatea, Tahaa, Huaheine, and Borabora, it was a real surprise to the present author to find novel forms in Moorea which are not mentioned in the literature, and which are entirely absent from the extensive collections made by Garrett, now distributed in the museums of Honolulu, Philadelphia, Washington, Cambridge, and Pittsburg.

Three of the new species are sinistral, thus agreeing with *P. mooreana*, which is dextral only in the case of rare, newly-discovered mutations, and also with numerous local associations of *P. suturalis*. Hence the island of Moorea supports more reversed species of the genus than are known to occur elsewhere throughout its entire range. The fourth novel species is predominately dextral, although exceedingly rare sinistral mutants have been found.

PARTULA TOHIVEANA, new species. Plate VI, figures 1-4.

Shell large, sinistral, elongate-conic, and perforate. Whorls 5 to $5\frac{1}{2}$, with flattened profile at the apex, becoming more convex with further growth; suture slightly impressed in most ex-

¹ Journ. Acad. Nat. Sciences, Philadelphia, Vol. IX, part I, 1884.

amples. The middle area of the last whorl is flattened or even indented immediately outside of the lip. Columella straight. The dense, finely-sculptured lines of the younger whorls disappear toward the body-whorl which is therefore smooth and shining in undecorticated specimens.

Aperture elongated, with its long axis inclined away from the columellar axis. Lip rounded or slightly beveled, thickened inwardly, sharply angled at the columellar insertion, and dented near its outer insertion; the toothed appearance is accentuated by the sudden narrowing of the outer peristome toward its junction with the last whorl. A thin, shining callus spreads over the body-whorl between the two insertions of the lip. A parietal tooth is well developed almost universally.

Colors: (a) corneous yellow or light corneous-brown, with or without darker coloring of the apical whorls, and in some specimens with sparse darker transverse lines (Plate VI, fig. 1); (b) similar in ground color and with two, sometimes four, vaguely-defined revolving bands of chocolate-brown (Plate VI, figs. 2, 3); (c) with a revolving median zone of chocolate-brown upon the usual background (Plate VI, fig. 4). The lip is white, smooth, and shining.

The shells of half-grown individuals have the outer wall plainly angled, although this feature disappears on the later-formed whorls. The embryonic young are always unbanded, either white or faintly corneous, with or without a colored tip. The bands of fasciated adults appear only in post-embryonic life, and they seem to be relics of an antecedent dark general color. Embryonic capsule impregnated with calcareous substance so as to be opaque.

Dimensions as follows:

Length 17.4–23.7 mm., average 21.68 mm.

Width 10.1–13.7 mm., average 12.08 mm.

Length of aperture 8.9–12.5 mm., average 11.06 mm.

Width of aperture 6.7–9.3 mm., average 7.98 mm.

Proportions of shell 49.5–60.5 per cent, average 55.65 per cent.

Proportions of aperture 65.5–78.5 per cent, average 72.04 per cent.

Proportions of aperture-length to shell-length 47.5–55.5 per cent, average 50.95 per cent.

Habitat: Moorea, Society Islands; lower slopes of Mt. Tohivea.

This species presents several features of special interest. In the first place, in the writer's experience it exists only in a very limited area of bush on the lower northern slopes of Mt. Tohivea, which is the dominating mountain of the island. In July of 1923 a few hundred specimens of various ages were taken in an area not more than four hundred yards in lateral extent, between 700 feet and 900 feet above sea level. Despite the fact that the natives of Moorea, as elsewhere in the Society Islands, are collectors of shells to be made into necklaces and wreaths, the new species was entirely unknown to them.

Intrinsic noteworthy features are the roundly dentated outer lip, and the simple conical contour of the youngest whorls, in which characters *P. tohiveana* resembles the dextral species *P. dentifera* and *P. formosa* that live in the island of Raiatea, more than a hundred miles to the west-northwest of Moorea. The resemblances in these distinctive qualities suggest that the Moorea and Raiatea forms displaying them are descended from a common ancestral stock, comprising animals of both coils like *P. otaheitana* and *P. suturalis* as they exist today, and which ranged over a larger body of land connecting the two islands in former ages. At the northwestern end of this former land, where Raiatea remains, the present derivatives have retained the dextral coil, while at the eastern end, which is now the separated island of Moorea, the animals are reversed. Under the geographic and other circumstances, *P. tohiveana* cannot be a direct product of Raiatean ancestry; and it is equally clear that the Raiatea species with the characteristics in question are not the descendants of direct migrants from Moorea.

PARTULA OLYMPIA, new species. Plate VI, figures 5–8.

Shell sinistral, ovate-conic, more compact than in *P. tohiveana*; compressly perforate. Whorls 5 to $5\frac{1}{2}$, convex throughout, suture of the body-whorl impressed. The middle part of the last whorl is depressed just before it meets the flaring lip,

as in *tohiveana*. Columella twisted slightly,—a feature more evident in adolescent than in adult shells. The spiral sculpturing continues from the youngest whorls to the very edge of the lip.

Aperture elliptical, axis parallel to the columellar axis. Lip rounded or slightly beveled, thickened inwardly, broad at its columellar insertion and narrowed toward its outer insertion, but not so markedly as in *tohiveana*. A shining callus occurs between the two insertions, finely pitted under the lens. A parietal tooth occurs in all but a few of the shells, but it is not prominent.

Colors: (a) uniform fleshy corneous; (b) uniform medium brown; (c) same in basis, with a median band of brown on the whorls of the spire only (Plate VI, fig. 5); (d) similar in ground-color, with a vague median band of brown which extends over the body whorl as well as on the upper coils (Plate VI, figs. 6, 7); (e) ground color as before, with two revolving bands of brown, weak and vaguely defined (Plate VI, fig. 8). The lip is white.

The outer wall of the adolescent shell displays a median angle. The revolving colors of fasciated individuals appear on the embryonic shell, in which respect they differ from the bands of deeper tint in *tohiveana*. The embryonic capsule is opaque.

Dimensions of thirty-one measurable shells as follows:

Length 17.7–20.4 mm., average 18.94 mm.

Width 10.3–11.9 mm., average 10.99 mm.

Length of aperture 9.1–10.9 mm., average 9.99 mm.

Width of aperture 6.7–8.1 mm., average 7.43 mm.

Proportions of shell 53.5–62.5 per cent, average 58.14 per cent.

Proportions of aperture 70.5–80.5 per cent, average 74.37 per cent.

Proportions of aperture length to shell length 49.5–56.5 per cent, average 53.63 per cent.

Habitat: Moorea, Society Islands: inner slopes of Mt. Moua-puta at high levels.

On first inspection the present species appears to be very close to *P. tohiveana*, but on further study it proves to be clearly dis-

inct. The two species are alike in sinistral coil, narrowed outer insertion of the lip, depressed median body-whorl outside of the lip, and in the general coloration of certain subordinate classes. But *P. olympia* differs in its more compact form, straighter aperture, convex apical whorls, its delicate sculpturing throughout the whole shell, and in the earliest possible appearance of the revolving bands when they occur. Hence *P. olympia* is no nearer to *tohiveana* than it is to the far more abundant *P. mooreana* of the same island.

Less than a hundred examples of all ages have been taken. They were discovered in 1919 in a restricted area of forest about 900 feet above sea-level, on the inward or northern slopes of Mt. Mouaputa. This mountain stands about two miles from Mt. Tohivea with which it is connected by a portion of the ancient wall of the huge central crater of the island. The forests are virtually continuous between the localities of *olympia* and *tohiveana*, but no sinistral snails belonging to these or to any other species were found in the intervening territory. The natives had never found the type, so far as could be ascertained; the specific name is conferred because they believe that the mountain of Mouaputa is the dwelling-place of invisible supernatural beings.

PARTULA DENDROICA, new species. Plate VI, figures 9-13.

Shell sinistral, oblong-conic, compressly perforate. Whorls $5\frac{1}{4}$ to $5\frac{1}{2}$, slightly convex, the last conspicuously slender. Suture impressed, more markedly on the last whorls. Columella sinuous. Surface shining and generally smooth, as if polished; spiral sculpturing weak, and obsolescent on the last whorl.

Aperture oval, not inclined. Lip rounded, slightly thickened within, channeled at its columellar junction, and evenly curving to the neighborhood of its outer insertion where it turns inward more abruptly. The callus over the body-whorl is very thin. Parietal tooth entirely wanting, or very weakly developed in a small percentage of the specimens.

The color classes are clearly differentiated, as follows: (a) uniform light straw-yellow, with slightly darkened tip as a rule

(Plate VI, fig. 9); (*b*) uniform yellowish-brown, or brown (Plate VI, fig. 10); (*c*) yellowish-brown, with a single median band of deep brown, sharply defined on all excepting the youngest of the whorls (Plate VI, fig. 11); (*d*) like the foregoing in ground-color, with a broad median zone of deep brown color (Plate VI, fig. 12); (*e*) yellowish-brown or brown, with four revolving bands of deeper brown, one near the suture, one near the base, and two intermediate (Plate VI, fig. 13).

The metaneanic whorls are not angled as in *tokiveana* and *olympia*. Fasciation begins with the embryonic stages. The embryonic capsule is opaque.

Dimensions of the entire series of adult shells in hand, eighty-six in all, as follows:

Length 18.9–23.4 mm., average 20.45 mm.

Width 10.3–12.5 mm., average 11.29 mm.

Length of aperture 9.9–11.7 mm., average 10.74 mm.

Width of aperture 7.1–8.9 mm., average 8.06 mm.

Proportions of shell 46.5–61.5 per cent, average 55.17 per cent.

Proportions of aperture 66.5–81.5 per cent, average 75.00 per cent.

Proportions of aperture-length to shell-length 46.5–58.5 per cent, average 52.44 per cent.

Habitat: Moorea, Society Islands; southern and southwestern aspects of Mt. Rotui, at high levels.

This species was first discovered in 1909, when it was supposed to be a local variant of *P. suturalis* Pfeiffer, which it resembles in some features. While *P. dendroica* and *P. suturalis* may be connected through a common remote ancestry, there can be no question that the differences they now exhibit justify their separation as distinct species.

Mt. Rotui is a lofty mass of volcanic rock situated between the two bays of Faatoai or Opunohu and Paopao which indent the northern side of Moorea. It is interpretable as a sector of an original crater which has long been disconnected from the semicircle comprising the high peaks of Mt. Tohivea and Mouaputa, where the previously-described species occur. The areas where *P. dendroica* was found lie in a zone of dense vegetation

on the abrupt southern slopes of Mt. Rotui. The snails live on the high shrubs and trees, and are rarely taken on the plants of lower growth where *P. tæniata* and other species are found. The specific name is given on account of the tree-dwelling habits of the species. Probably the habits in question and the local occurrence of the species are responsible for Garrett's failure to discover *dendroica*.

From seven points within the inhabited area, representative collections have been secured which comprise more than two hundred individuals of adult and adolescent growth. The several associations differ much as regards the number and relative frequencies of their component color-classes. In brief, *P. dendroica* surpasses *P. tohiveana* and *P. olympia* in its geographical extension and in its local differentiation, although it falls far short of the other species of Moorea in both of these respects.

PARTULA MIRABILIS, new species. Plate VI, figures 14-20.

Shell dextral (reversed in rare mutations); ovate-conic to elongate-conic, openly or compressly perforate. Whorls 5, slightly convex, the body-whorl flattened toward the lip; suture of the last whorl impressed. The surface is sculptured throughout, but the lines are fewer on the larger whorls, which are shining and generally smooth except in decorticated specimens.

Aperture narrowed, elongated, almost oblong in general outline. Lip sharply beveled, thin, and smooth. A thin, roughened callus spreads between the insertions of the lip. Parietal tooth present in almost all instances, but it is seldom prominent.

Colors: (a) corneous fleshy, apex pale brown (Plate VI, fig. 14); (b) pale brown, with deeper brown transverse strigations (Plate VI, fig. 15), (c) corneous brown, with darker brown, ruddy, or rose-brown spire; (d) deep chocolate brown or seal brown, the spire usually lighter (Plate VI, fig. 16); (e) light brown, with three revolving bands of deeper brown color, and usually with sutural and basal clouding (Plate VI, fig. 17); (f) encircled by a broad zone of deep brown color, which is separated from the brown sutural and basal areas by narrow corneous lines, often with an asymetrical revolving corneous line through

the median line itself (Plate VI, fig. 18); (*g*) deep seal-brown in general, with a revolving corneous zone toward the base and just within the suture of the upper whorls (Plate VI, fig. 19); (*h*) brown, save for a median revolving area which is corneous (Plate VI, fig. 20). The lip is white in the lighter-colored classes, and stained with brown or purplish-brown in the darker divisions.

Embryonic young are either brown of various shades, or they are clearly girdled by a central zone of darker color; the latter condition develops into the several forms of final adult fasciation. The egg capsule is opaque.

Dimensions are here given as the extreme measures of the few hundred shells already analyzed, as follows:

Length 14.1–18.6 mm.

Width 8.3–10.7 mm.

Length of aperture 7.5–10.1 mm.

Width of aperture 5.1–7.1 mm.

Proportions of shell 51.5–65.5 per cent.

Proportions of aperture 61.5–79.5 per cent.

Proportions of aperture length to shell length 46.5–59.5 per cent.

Habitat: Moorea, Society Islands: several subordinate localities within the central crater valley of Opunohu, and in some adjacent areas.

This species receives its name in recognition of certain remarkable features of its intrinsic nature and distribution. In the first connection, the notable point is its striking differentiation in the characteristics of coloration; no less than eight color-classes can be distinguished, and some of these are not duplicated in any other species of the Society Islands. These color-classes vary in number and relative abundance in the several local associations, which therefore present very different aspects even in neighboring valleys. The aperture is exceptionally narrow for a species of *Partula*, while the beveled nature of the lip is another distinctive feature.

It seems certain that Garrett possessed no examples of this species, for nothing of the kind is mentioned in his writings or in his correspondence with Hartman and others, and the species

is entirely lacking in the abundant series of shells sent by Garrett to conchologists. Yet at the present time the total area of its occupation extends over some miles of territory, in which the animals occur in greater numbers at the higher levels. From the observations of the present writer during the years from 1907 to 1923, it is certain that the species has spread into this wider territory from a central region that must have been so small in Garrett's time as to escape the scrutiny of that careful explorer and observer; in short, the condition of *P. mirabilis* some decades ago must have been like that of *P. tohiveana* and *P. olympia* at the present time, although *mirabilis* has extended its range and it has differentiated into diverse colonial associations as the other species have not as yet.

The full statement of the structural qualities and color-characteristics of *mirabilis* must await the complete analysis of the material now in hand, which comprises several thousand individuals. The data given in the foregoing account sufficiently define the species and indicate its noteworthy features.

EXPLANATION OF PLATE VI

Figs. 1-4. *Partula tohiveana*, new species.

Figs. 5-8. *Partula olympia*, new species.

Figs. 9-13. *Partula dendroica*, new species.

Figs. 14-20. *Partula mirabilis*, new species.

A BUCKET DREDGE

BY CHARLES HEDLEY

I suppose that all zoologists who have worked in water deeper than a hundred fathoms have found trouble with their gear. Especially is this the case with people who, like myself, began to dredge without tuition or any help from experienced men. Sometimes a dredge returns without a spoonful of shells, although the polished metal certifies that it has been rubbed on the bottom. A dredge that goes overboard so neatly may return with the tail wrapped in the mouth or the wire rope may be twisted and tangled.